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ABSTRACT

The case of Singapore illustrates how well-deployed information technology (IT) can be a change agent in education and national development. IT has been a catalyst and enabler of the shift from didactic, passive instruction to interactive, learner-centered and learner-directed instruction. In technical education in particular, IT has served as a new tool/facility, valuable educational resource, integral component of education and training, and stimulant and vehicle of knowledge creation. IT has facilitated infrastructure development and economic growth both directly and indirectly via education. Of 55 major cities surveyed worldwide, Singapore ranked fourth in computer and Internet usage. Singapore's IT 2000 Masterplan calls for establishing a host of multimedia services at competitive rates. Along with thinking skills development and national education, IT is one of the three priorities for Singapore's education plan, which calls for having 30% of the curriculum incorporate IT by 2002. IT has significantly improved the following aspects of Singapore's educational delivery system: administration; presentation; and communication. There are strong indications of a causal relationship between deployment of IT and significant improvements in Singapore's educational system and economy. Factors credited with Singapore's successful assimilation of IT include the following: goal definition, leadership/management, ownership, infrastructural provisions, training, incentives, and monitoring and evaluation. (MN)

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TEND 2000

Crossroads of the New Millennium

IT As A Change Agent In Education And National Development

Prepared and Presented

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Workshop 2

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Abstract

It is now generally acknowledged that the Tofflerian "3rd wave" has displaced the preceding historic wave of the industrial revolution. Undoubtedly, technology has become a most potent force, which within this decade has redefined concepts of time, space and even reality, consequently demanding radical shifts in mindsets and paradigms. It is relentlessly and rapidly changing the way we work and live, with its effects impinging on virtually all-human transactions. The potential of IT as a change agent is undeniably great and, well deployed; it is a powerful tool.

This paper will take stock of how it has impacted on two key and inseparable areas: education and national development. In this age when knowledge is critical to national growth and success, the workforce must necessarily be well schooled. Not surprisingly, then, countries around the world are making education a top priority and investing heavily in human resource development. IT is a key player here, offering as it does both quantitative and qualitative improvements over traditional pedagogy. It has profound implications for increased as well as extended access, the latter expanding education beyond the formal to the non-formal and enabling it to move from the 'life phase' to the recurrent model so necessary to sustain re-skilling and lifelong refreshing of knowledge. As important are the qualitative changes to the learning experience: the richness of resources and tools which makes possible new and innovative extension of the repertoire of teaching and learning approaches are well worth investigation.

Equally worth considering is how and to what extent these developments in education will contribute to national growth. Recently, the International Association for the Evaluation of Educational Achievement announced that its survey showed that Singapore topped the list in the use of IT in education. Singaporean students have also been repeatedly distinguishing themselves in the international arena, including the International Mathematics and Science Study. And the Singapore workforce has for many years now been ranked among the top few in the rigorous BERI survey. What is the correlation here? An examination of the causal relationships here may be informative.

How best to develop a country's human resources to meet these demands is an educational as well as political issue. What are the critical success factors? What are good strategies? How may education be best positioned to serve national needs? These are but some of the questions which can be asked and, hopefully, usefully discussed at an international conference such as this. In an increasingly borderless world, solutions must have a global perspective.

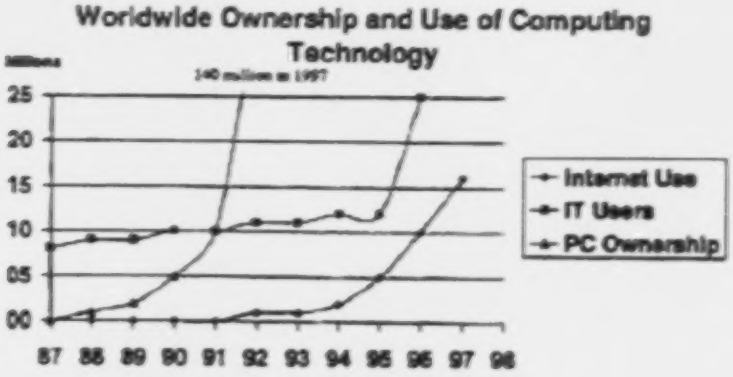
IT as a Change Agent in Education and National Development

PREAMBLE

The Digital Age

IT--the 3rd wave superseding the agricultural and industrial waves—has unmistakably redefined concepts of time, space and even reality, consequently demanding radical shifts in mindsets and paradigms. Particularly in the short space of the last decade, it has relentlessly and rapidly changed the way we work and live, impinging on virtually all-human transactions. This paper focuses on how technology has impacted on two keys and closely related areas: education and national development.

With the technology becoming more and more user-centred/friendly, the rate of adoption has correspondingly accelerated, as may be seen from the table below[1].



The Growth of Computer-Based Technologies

The growth has been not only quantitative but also qualitative. Progress in the technology has been nothing short of phenomenal. Moore's Law—that capability in terms of speed/power doubles every 18 months—may well become obsolete, with time becoming increasingly foreshortened. In a relatively short span, the industry has created a system that is dynamic and increasingly integrated, i.e. moving beyond personal computing and isolated systems to open and networked enterprises with tremendous implications for information distribution, communication and intra/cross-border co-operation.

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[1] Neef, Dale (1999). A Little Knowledge is a Dangerous Thing. Oxford:Butterworth-Heinemann, p40

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IT and Paradigm Shifts

Paralleling the tremendous technological growth are shifts in 3 key areas that impinge intimately and substantially on national development, viz. the geopolitical, the economic and the educational arenas. In all these three, the potential of IT as a change agent is undeniably great and, well deployed; it is a powerful tool

1. *Geopolitics*

   Major shifts in political power and alignments have emerged in the last few decades. Added to this is the IT-driven phenomenon of globalisation: the world has become increasingly open, volatile, and multipolar. As such, co-operation must necessarily coexist with competition. For instance, while countries must look to their own development, social environmental responsibilities require concerted and shared efforts.

2. *Economics*

   Market and national economics are being transformed in the 21st century. More and more, the 'marketplace' is borderless, thereby creating open competition and free enterprise within which responsiveness to change and market conditions, strategic alliances, selective co-operation and outsourcing are logical solutions. To function successfully, organisations need to be info-based and info-enabled.

   > ...the future scenario would be one where success depends on having knowledge and speed in responding to changes, which will impinge on every aspect of life. (Goh Chok Tong, Prime Minister, Singapore)[2]

3. *Education*

   Toffler drew attention to the shift from economic and political/military power to knowledge. This is the information age where "more and more the economy's added value will be created by brain rather than brawn."[3]. Concomitantly, Peter Drucker's "knowledge workers"[4] will be needed, as also continuous human resource adaptation

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2 speech delivered at the 7th Thinking Conference, Singapore, as reported in *Straits Times*, 3 June 1997

3 Tapscott, Don (1996). The Digital Economy: Promise and Peril in the age of networked intelligence. New York: McGraw-Hill.

4 Drucker, Peter (1993). Post Capitalist Society. Oxford: Butterworth-Heinemann.

and the capability for generating, managing and continuously upgrading knowledge to cope with its exponential growth. Hence, education is key player in delivering the core competencies. The paradigm shift in education is arguably most important and fundamental; it impacts on the other domains and is crucial to national development and viability.

IT AND EDUCATION

IT as Catalyst - Changing Environment and Skills

The changes following upon the rapid technologically driven developments are increasingly significant and evident. With the rapid pace, the learning curve has been compressed and market-readiness--e.g. adaptability, real-time performance—is necessary. More important, the changing workplace environment of a knowledge-based society demands a change in skill sets. The traditional 3Rs need to be enhanced with other capabilities such as creativity, analytical thinking, problem solving, IT literacy, entrepreneurial/technopreneurial and other 'life skills'.

Changing Desired Educational Outcomes

In an info-glut era, education must add value to its traditional information transfer; it is the ability to manage and use information that is critical for success. Educational aims must be redrafted to match these outcomes and the process of education reengineered. 'World ready' outputs have to meet the minimum specifications of the '3 L's':

1. *Life-skills oriented*

   Leadership, teamwork, networking, risk taking, time/stress/failure management, these are some of the necessary skills. Perhaps even more important is the mindset; we need to nurture individuals who think globally, dare to dream, have a 'can do' spirit, never say die, and are 'street-savvy' rather than just book-wise.

2. *Learning-enabled*

   Education now involves more than transmission of a body of information; it should develop the learner's ability to think and learn autonomously, and to manage his/her own learning. For this to happen, the learning culture has to be one that is learner-directed/controlled.

3. *Life-long capable*

Not only must individuals have the capacity for knowledge upgrading and re-skilling, they also need to acquire that habit of intellectual curiosity so that they will be self-directed in the life-long process of learning and prolonging the life of the mind. This involves extending education beyond the formal to the non-formal, from the 'life-phase' to a recurrent model that is so necessary for life-long refreshing of knowledge.

> The illiterate of the 21st Century will not be the individual who cannot read and write, but the one who cannot learn, unlearn and relearn." (Alvin Toffler)

Changing Paradigm

Much has been said about the necessary shift from didactic, passive instructionism to an interactive learner-centre and learner-directed approach, and it is unnecessary to elaborate on it here but perhaps a summary of the essentials might be useful.

Instruction Paradigm	Learning Paradigm
instructor-led/dependent/micro-managed	learner-led/self-directed
didactic/Prescriptive	active/discovery learning
extrinsically motivated	intrinsically motivated
Knowledge transmission/education as an end	learning how to learn/education as a means
Time-specific learning	continuous learning loops
Synchronous	asynchronous
classroom-bound/theoretical and decontextualised	real world/authentic problems/workplace integrated/access to practitioners
Coverage-dominated/curriculum-driven	mastery/distributed cognition
certification based on time on task	competency-based assessment

IT as Enabler

The changes are, of course, not entirely the result of IT, but IT is undoubtedly a major player, both as catalyst and enabler. It has undeniable potential through the range of tools it offers—Internet with its access to vast resources/expertise, networked workstations providing collaborative and communication tools, multimedia capabilities, simulations,

publishing tools, etc--changes in teaching/learning paradigms, processes and products have been facilitated by leveraging on its power. Sendov[5] identified 3 waves of IT in education:

1. *IT as a new tool/facility*

   This ranges from the relatively basic but highly efficient tools, e.g. word-processing, spreadsheets, databases, web-publishing to more sophisticated and larger-reach applications such as the those which make possible a well-organised electronic web infrastructure that can be used to capture, codify, organise, disseminate information where and when needed. Perhaps what is fundamentally significant is its interactive capability, which enables learning to be active/participative, and its "strategic agility" and tremendous potential as a communication tool.

2. *IT as valuable educational resource*

   The second wave capitalises on IT's potential for knowledge collecting and distribution and moves more clearly into the pedagogic circle, 'infiltrating' into existing disciplines though such means as CAL packages, Internet, CD-ROMs, commercial databases.

3. *IT as integral component*

   Advanced computing and telecommunications technologies--introducing email, online chats, discussion groups, computer/video conferencing, etc--have contributed greatly to the pace and magnitude of changes in the educational arena, ushering in the third wave which powers technology beyond being an accessory to being a force that shapes the very nature of the teaching/learning transaction, influencing for instance, content, methods and systems of teaching.

To this might be added a 4th and very important wave:

4. *IT and knowledge creation*

   The knowledge framework with its capacity for stimulating and supporting investigation and research generates continuous growth in our knowledge base. Medical science, for instance, has seen radical growth. Researchers, for instance, recently reported having learnt to grown brain cells on silicon chips, wiring living neurons to silicon circuitry. This could have tremendous implications for the use

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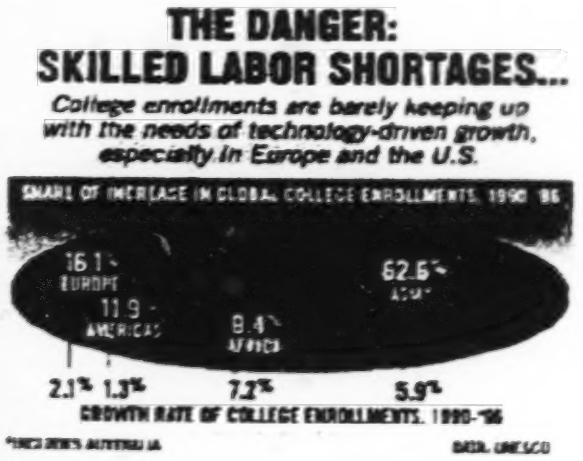
Sendov, B (1986). The second wave: problems of computer education. In R Ennals, R Gwyn and L Adravchev (eds.) Information Technology and Education. Chichester: Ellis Horwood

of electronic devices in reconnecting severed spinal cords to reverse paralysis. The decoding of human genome and the potential for gene therapy is yet another exciting area leveraging on the power of IT.

> Obviously the development of computing and telecommunications technologies has been central to this knowledge-based revolution...changes are coming about because of the way in which educated, knowledgeable, and creative people are now concentrated, rewarded and governed. It has been the mass leverage of knowledge workers that has created this global, knowledge-based revolution.[6]

Education and National Development

More and more, economic and national health is dependent on high-ability educational systems to provide high-ability workers suitably equipped with intellectual, creative and technical capabilities. Furthermore, the challenges and problems of today demand more response from a collective intelligence, a group working collaboratively and synergistically, rather than individuals working on their own. The one-chief-many-workers model is increasingly being replaced by flatter organisations within which expertise resides at all levels. Attention to training adequate manpower is therefore imperative.



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[6] Dale Neef (1999). A Little Knowledge is a Dangerous Thing, p2.

IT AND NATIONAL DEVELOPMENT

The connection between IT and national development—directly or indirectly via education--is easy to see.

Infrastructure Development

In various ways IT is adding to national assets and shaping the social and economic value-added structure. It impinges significantly on social interaction, communication, business transaction, leisure options and other domains. While there are some misgivings, it is generally conceded that an IT-supported environment is a better living and business environment.

> IT will bring democracy to China...pushing in order to open up Chinese society.... There is no question that with the spread of the Internet and globalisation, the spread of information, there is no way to keep that out of China if China is going to compete economically...(Madeline Albright)

Economic Growth

An efficient IT-driven communication infrastructure is important in a knowledge-based economy that is highly dependent on fast and timely information flow and distribution. More specifically, technology supports and sustains economic growth in such ways as enabling increase in productivity and efficiency (e.g. through IT-supported administrative procedures), cost-effective use of knowledge/expertise through rapid/large-scale skills transfer, enhancing quality assurance and stimulating innovation in industry.

IT is also clearly critical to the management of globalisation. And with the need for agile responses to rapid changes in the 'marketplace' and its dictates, whether the 'high road' (larger and more global) or 'low road' (smaller and domestic) will substantially determine the wealth of nations.

CASE STUDY: THE SINGAPORE EXPERIENCE

Singapore: a 'Smart' Island?

The IT scene is certainly very vibrant. Singapore is rated among the 10 "hot new top tech cities"[7] and ranked 4th out of 55 surveyed worldwide[8]--based on computer and Internet usage,

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7 *Newsweek* Nov 9, 1999

8 survey conducted by International Data Corp

social aspects of IT and government policy—and expected to move up to 2nd place in 2001. PC/Internet penetration is relatively high, ahead of such countries as US, Australia and Japan[9].

Its **IT 2000 Masterplan** is a fairly ambitious one which includes, among other things:

- setting up a host of multimedia services—e.g. Internet, video-on-demand--at rates made competitive by liberalising telecommunications and inviting multiple service providers;
- building 'Singapore ONE'—Singapore-One-Network-for-Everyone—which provides a national high-capacity broadband network platform to transform Singapore into an intelligent environment with state-of-the-art technologies delivering a potentially unlimited range of multimedia services to the workplace, school and home. Offering a host of incentives--such as preferential tariffs for broadband connectivity, tax incentive, investment allowance, subsidy under the Innovation Development Scheme, joint publicity programmes--it has secured the participation of fourteen leading content, service and technology providers (Microsoft, IBM, Sun Microsystems, Motorola, HP, etc). Broadband, ATM backbone with core ATM switching are now in place to support high volume electronic traffic and a host of applications and services, including high-speed Internet services, online access to government agencies, school curricula and educational information.

IT and the Singapore Education System

IT is evidently a key player. It is one of the three priorities for Singapore education system, the other two being thinking skills development and national education.

IT-for-Education Masterplan

The Masterplan for IT in education is underpinned by the belief that education should anticipate and address the future needs of society. Launched in April 1997 with a S$2 billion budget, provides the blueprint for integrating technology into teaching and learning and aims to create 'smart' schools by 2001. It defined 4 key dimensions:

1. curriculum and assessment

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survey by Infocomm Development Authority of Singapore, 4th IT Household Survey (June 99)

- PC: Sing (59% of households), US (54%), Aus (47%), Japan (42%)
- Main uses of computer: email (87%), games (56%), info retrieval on hobbies (35%)
- Internet penetration: Sing (42%), US (40%), Aus (22%) Jap (13%)
- Main uses of Internet: email/chat (87%), info retrieval (70%), news (25%), web applications (20%), online gaming/watching movies (17%)

2. content and learning resource
3. physical and technological infrastructure
4. human resource development (Core Training for all teachers)

The push to leverage on IT for teaching and learning has been unremitting and there is substantial progress:

Phase I: 1997	IT was integrated into the curricula of 10 primary and 10 secondary schools and 2 junior colleges, with it forming at least 10% of the curriculum time.
Phase II: 1998	106 schools came on board.
Phase III: 1999	Further investments in start-up hardware, networks (e.g. whole-school networking), software and courseware, training of teachers, and upgrading facilities for high speed Internet access. 230 schools became involved in integrating IT into curriculum.
by 2000	Projected student:computer ratio is 6.6:1 in primary, and 5:1 in secondary schools. Core training for all teachers is expected to be completed.
by 2002	The targeted student:computer ratio will be 2:1, and 30% of curriculum time will incorporate IT.

IT-Supported Education in Singapore: a Success Story?

The way we teach and the way students learn is slowly but surely changing, slowly because it is never easy to change mindsets and old habits die hard: we teach as we have been taught. But IT-mediated changes are becoming evident and gathering momentum. IT-mediated changes are gathering momentum and becoming evident, notably in the following ways.

- *It has expanded the repertoire of tools.*
  i) <u>Administration</u>

  The Electronic Office Management System at the National University of Singapore has simplified and expedited registration for courses and examinations,

result retrieval, student feedback, and provided electronic records and workflow management in such areas as payment, leave applications, research project submission, research publication updates, work order requests, stationery requisition, and software acquisition.

ii) Presentation

IT-enhanced presentations, facilitated by upgrading of software and equipment has introduced a level of sophistication not known in the pre-Powerpoint era. Some feel, however, may not be more than a cosmetic change and have asked: "where's the power and what's the point". This reinforces the importance of pedagogy-driven applications and uses; care must be taken so that IT is not the proverbial tail wagging the education dog.

iii) Communication

This is arguably the most significant. With Internet and Intranet with client/server-based integrated information systems, communication—including real-time interactivity through ICQ, chat rooms, videoconferencing, web-conferencing, etc—is greatly enhanced. With multimedia technologies, high performance computing and visualisation support and high volume data transfer services, the potential for alternative delivery systems is great. More and more, live sharing of applications and documents is providing the edge over the "relatively slow e-mail".

- *There is greater variety and flexibility in the delivery system.*

The technology has arrived at a level of maturity where it is possible to have anytime, anyplace access, creating effective an expanded and potentially borderless learning space and prompting redefinition of the `classroom'. Worth noting too is the move from 1-way delivery to increasingly greater degrees of interactivity. As real mastery is more likely to derive from active engagement, this is an important consideration. The National University of Singapore, as an example, has introduced a number of initiatives, e.g.

- Integrated Virtual Learning Environment: a web-based environment housing course web sites (866), Course Outlines (1201), 245 Discussion Forums (245);

Chat Rooms (96); Workbins (114)[10], on-demand services such as video-on-demand and lecture-on-demand; remote lecturing: 'live' webcasting of lectures (July-Oct '99: 116 full lectures).

- 'Global campus': a project introducing ubiquitous access through >8000 Plug-&-Play live network points located throughout the campus.
- notebook ownership scheme: loans are provided to assist students in acquiring personal notebooks, with support service and technology built into the package.
- distance learning, e.g. a Master's course in electrical engineering for Motorola engineers delivered through multimedia conferencing via the Singapore-ONE network.
- 'Global Learning Consortium': a hub for international learning network promoting exchange of learning programmes of which the university if a member.

The other tertiary institutions in Singapore are likewise strongly committed, and likewise have adopted technology not only for on-site but also distance teaching and collaboration on project work. Singapore Polytechnic's 'Virtual College' offers courses taught using the Internet, Temasek Polytechnic's Centre for IT in Education and Learning has an 'Online Learning Environment' for delivering a range of internal and external courses. Ngee Ann Polytechnic's 'NP-ONE' is a web-based, adult industrial training programme delivered in the distance mode.

There is also a high level of activity in the schools. Not only is there computer-supported learning (e.g. virtual laboratories, the multimedia, content-rich 'Student-Teacher Workbench') but there are also efforts at using IT tools for cross-classroom activities. Raffles Girls' School is offering some classes on the net so that students across the island can learn in the virtual classroom of this premier school. Collaborative learning is gaining momentum, e.g. the 'Asia-Europe classroom' brings together 25 schools worldwide to learn interactively via Net telephony and videoconference, the AT & T virtual Classroom has been set up for a multi-party global water study. Various software which allow students to work on projects with students in other countries have been developed/adopted to facilitate such collaboration. Schools are also aggressively exploring new technologies. For instance, Raffles Girls School, worked with Hewlett Packard in an e-learning project in which students doing all their schoolwork on hand-held PCs (Jornada) supplied with a wireless network card, offering

[10] The numbers were taken in October 99.

e-mail, Internet, word-processing, spreadsheet presentation and organiser functions. This is now taken to a larger scale and user population with the development of another wireless communication device: the Edupad (15 MB, 800 gm) which has capabilities for internet access, e-mailing, scheduling, etc. and functions also as a notepad with handwriting recognition software. With this also comes the possibility of highly portable digitised textbooks.

There are also commercially driven projects, such as live interactive tutoring and 'Educast' which is an educational programme for children combining TV, radio, Net-based interactivity.

- *Instructional materials and approaches are enriched.*

  Web-based lessons, electronic discussion groups have increased the instructional repertoire. Multimedia technologies, online resources and CD-ROMs have the potential for more interesting/multimedia recreations. For instance, some history lessons are available online via Singapore-ONE, and virtual labs for online simulated experiments have been set up and may be accessed from home. With the emergence of new technologies and the viability of networked multimedia platforms and virtual environments, there is new scope for reassessing and deploying the IT resources for on-site and distance teaching/learning.

- *Knowledge base has increased.*

  Improvements in protocol and interoperability have contributed greatly to increased access to Internet-based and Web-based resources. Through links to corporate databases, file servers, and document repositories, broad-spectrum information is made available to users through a single, transparent front end. IT-enhanced digital libraries bring information through a network of borderless libraries and information providers to supply timely information, resources and library-related services in an integrated, transparent and convenient manner.

- *Distribution of and access to information has been extended.*

  As the technology becomes more affordable and accessible, the whole issue of access to education takes on new possibilities, with implications for knowledge sharing and equity. Of course, the issue of equity is a rather fraught one and much has been said about technology creating the great divide between the haves and have-nots, but that is subject for another paper.

The bottom line is that, reservations and qualifications not withstanding, there is impressive evidence of the transformation of teaching and learning through such means as:

- enhancing course, curriculum and learning; (from text to multiple representations, from passive reception to engagement; classroom to real world;
- providing efficient/cost-effective information-transfer which then frees up time and energy for developing higher order cognitive skills, thereby serving as catalyst/enabler of quality learning experiences.

The real long-term academic benefit of IT will be what it brings to pedagogy and the curriculum, e.g. whether the additional resources enhance the instructional tools used by teachers and the learning experience of students.

Education and National Development

Astonishing developments in information and communication technology (ICT) in the past few years... (means that) companies that are slow to react to these changes lose their market share quickly.... Speed, information and entrepreneurial dare are now the key success factors of a knowledge-based corporation. (George Yeo, Minister for Trade and Industry, at the opening of Dell Computer's Web Farm, 16 Feb '00).

Recognising the core competencies necessary for survival, Singapore invests heavily—20.52% of total government expenditure--in education[11] of national spending in education, and is constantly looking at how its educational system might be kept relevant and 'cutting edge' so that it can produce the requisite manpower. It seems to be succeeding fairly well in this, judging from this competitiveness ranking for 1999.

Competitiveness rankings in 1999		Primary school enrolment		Secondary school enrolment		Average years of schooling		Adult literacy rates in 1997	
Rank	Country	Rank	Country	Rank	Country	Rank	Country	Country	Percentage
1	SINGAPORE	1	Japan	1	Britain	1	Japan	South Korea	98
2	United States	1	Taiwan	19	Japan	10	Taiwan	Thailand	93
3	Hong Kong	1	Philippines	23	United States	15	SINGAPORE	Philippines	94
4	Taiwan	16	Britain	25	Taiwan	18	United States	Hongkong	76
5	Britain	20	United States	28	SINGAPORE	23	Philippines	Vietnam	91
24	Japan	31	SINGAPORE	57	Hongkong	28	Hongkong	SINGAPORE	88
37	Philippines	38	Hongkong	64	Philippines	32	Britain	Sri Lanka	90

NOTE: * Ranked out of 46 Source: WORLD ECONOMIC FORUM and UNDP HUMAN DEVELOPMENT REPORT 1998

[11] expenditure on education: S$3944.04 million (operating) and S$2006.89 million (development); total: S$5950.53 million, 2nd only to defense (S$7423 million); approximately 22% of total government expenditure: S$28994.94 million (Budget 2000 announced in parliament, 25 February, 2000), 3.6% of GDP;

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Singapore's educational system is predicated on both developmental and functionalist assumptions: it serves both personal as well as national needs. This is evident in the articulated functions of its universities which are all public institutions,

1. to produce the graduate manpower for our high-tech, knowledge economy
2. to educate Singaporeans to be global workers but local citizens contributing actively to Singapore
3. to be creators of new knowledge and applications.

As Deputy Prime Minister, Dr Tony Tan, emphasised

> As we make the transition to a knowledge-driven economy, intellectual capital is a key factor of production which increasingly contributes to the bulk of economic returns.... A mark of a world-class university is its first-rate research...to generate high tech spin-off companies and produce graduates who can create their own jobs. (lecture at Chulalongkorn University, Thailand, 14 Jan '00)

A great deal of attention to improving the educational level of its population. The numbers going for tertiary education continues to increase and presently represents about 20% of each cohort of students. About 10000 enter the local universities, 5000 go to institutions overseas, 1400 are enrolled in the Open University degree programmes and a substantial number[12] are pursuing programmes by distance learning. Additionally, about 18000 attend the polytechnics and nearly 4000 enroll at the Institute of Technical Education.

Attention is also being given to non-formal education, particularly to on-the-job training, skills upgrading and re-skilling. One novel initiative is a coach equipped with computers and digital cameras which visits factories all over the island to teach workers IT skills. On a much larger scale, more than S$50 million go into the Skills Development Fund, Education and Training Fund, and employers are also strongly urged to provide for training and development of their employees. The Public Utilities Board, for instance, recently announced that it will invest S$3.6m on training its staff to be multi-skilled and nimble workers who can adapt to new technologies, budgeting on about $1700/head and 12.5 days training per employee/year. This emphasis on life-long learning for continuous knowledge/skills refreshment has contributed to a long shelf-life workforce.

IT Education ⇔ National Development

While there is as yet no conclusive empirical evidence, there is reason to believe in the causal relationship among these phenomena:

[12] In 1998, 18000 took external basic degrees, while 4400 took external higher degrees.

- Singapore topped list in use of IT in education (International Association for the Evaluation of Educational Achievement survey).
- Its students fare very well in international ranking (e.g. at international competitions and surveys such as the International Mathematics and Science Study).
- Its workforce has for 20 years running been ranked #1 in the rigorous BERI survey.
- *Fortune* and the Economist Intelligence Unit rank Singapore as Asia's "top business city".

Somewhat more controversial is the growing complexity of social systems. Globalisation has implications for traditional national boundaries and values which need to be addressed. In an increasingly borderless world where people become citizens of the world, national identity and loyalties may become less clearly defined. That Singapore is aware of this is reflected in the inclusion of such clauses as "think globally but rooted in Singapore", "love Singapore", "Know and believe in Singapore" in the definition of the 'Desired Outcomes of Education' formulated by the Ministry of Education in April 1998. How well the introduction of national education as a strategy for achieving these outcomes remains to be seen. A recent study indicated that most Singaporeans are proud to be Singaporeans, but 1 in 2 Singaporeans also see themselves as citizens of the world.

CONCLUSION

There is little doubt that IT can be a powerful and positive change agent. . As with all powerful tools it has to be used judiciously. Well deployed it can improve the quality of life; ineptly applied it will be costly and counter-productive. Some critical success factors might be shared here.

Some Critical Success Factors

In 1999, Singapore spent about 2.5% of its GDP on IT, and though it is only approximately half of the figures for countries like US and UK its venture into IT is nonetheless a fairly ambitious one. Its experience in the implementation of its national IT Masterplan and the IT-for-Education Masterplan has been generally favourable. That this is so may be attributed to various factors, including attention the following.

Goal definition

This makes possible a shared vision and concerted efforts at arriving at common goals. Particularly where education is concerned, being focused on the learning outcomes helps to ensure that the technology does not dazzle and distract, is pedagogy-driven, integrated into the curriculum and focused on the essential, namely education.

Leadership/Management

For clear directions, there needs to be strong and visionary leadership. Technology is costly and isolated 'small players' will not be cost-efficient. 'Top level' decision-making and support will mobilise a critical mass for expeditious implementation. Furthermore, it is not enough for management to support but it must also be seen to support, either through resource provision or the reward system.

Ownership

While top-down decisions are efficient, effective implementation requires also the 'buying in' of all stakeholders. In the educational arena, for instance, success of its IT Masterplan depends on not only providing the infrastructure and hardware are but also commitment from teachers, students, the parents, employers, i.e. all involved in either the front or back end of the educational process. Hence, at the National University of Singapore, for instance, much effort—through 'road shows', workshops, seminars, forums, etc--goes into informing users of available IT resources and how these might be usefully deployed for teaching and learning.

Infrastructural provisions

As has been said, there is no such thing as too much bandwidth or too much memory. The more the technology advances, the greater the demands on it. The introduction of ADSL and broadband to Singapore did not satisfy the clamour for quicker and yet quicker access, so in a sense no provision is ever adequate. However, some minimum requirement must be met, such as affordability, user-friendliness, and a fair degree of system robustness and established standards and protocols.

Training

It is obvious—and perhaps often overlooked because of its obviousness—that merely providing people with hardware will not be productive if users are not ready. Training and user-support are critical.

Incentives

This is another obvious critical factor: changing mindsets and habits is difficult. Unless there are perceived advantages inertia will prevail. In education, for instance, courseware development is time-consuming and unless there is commensurate recognition built into the reward system, progress will be slow. At the National University of Singapore, for instance, such efforts are being taken into account in the annual staff review and awards are also given. If the suggestion for time-off for development is taken, it should be a powerful motivator as, often, the spirit may be willing but time is the constraint.

Monitoring and evaluation

One danger with the rapid pace of development is that it is only too easy to be so engrossed in keeping up that critical functions like monitoring and evaluation are neglected. It is useful to heed Stephen Ehrmann's[13] warning that "without asking hard questions about learning, technology remains an unguided missile". Building accountability in services, support and usage of IT resources, establishing mechanism for checking that developments are on target and on course, periodically evaluating (cost-benefit analysis, surveys, etc), are some ways of avoiding falling into the pit.

Some Concerns

Increasingly, questions are raised about how IT may impact negatively on the quality of life. At a macro level, it can widen social inequality, and may create problems of national identities and loyalties in a world moving towards borderlessness. It can pose real threats to privacy and produce pressures of knowledge explosion and 'infoglut'. It can alter the texture and quality of human interaction: reducing human interface and with it the atrophy of communication skills and the transmission of values traditionally effected through interaction. An increasingly virtual society wherein it is easier to evade social and moral accountability can contribute to value erosion and increase in crime rate. Techno-addiction, cyberporn are some of the less desirable parts of the vocabulary of the information age.

There is also the danger that 'glitzy' technology may seduce us into thinking that IT is the ultimate solution whereas 'smart' machines do not automatically/necessarily effect learning, not get the job done. Technology is a tool, and there has to be very clear-sighted vision of

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how best to use them to achieve the desired goals. A great deal of thinking has gone into this, but a great deal more needs to be done, as there is as yet no definitive model.

In sharing Singapore's experience, some good practices have been identified. Undoubtedly there are others, just as there are also pitfalls to consider. The recent visit of the Prime Minister of Singapore to the UAE highlighted the interests that the two countries have in common, and the potential for co-operation in various important areas including Internet development, e-commerce and human resource management. It follows that the sharing of experiences is likely to be mutually useful. But beyond that, the experiences should also be of interest at a global level in view of the inescapable interconnectedness of the world today. An international conference like this, therefore, provides good opportunity for collaborative learning and it is hoped that this paper will trigger fruitful discussion.